

in the spectrum of  $\Sigma. 5$  with the magnesium fluting of nearly the same wave-length, and I am glad to say that my observations were in accordance with your own." . . . . "On comparing the brightest line with the magnesium fluting, both directly and by aid of the micrometer wire, the line was seen to be well within the limits of the fluting, and separated by a small but unmistakable interval from its bright lower edge. The appearance was the same on both sides of the grating, and in the 3rd and 4th spectra. The comparison apparatus was carefully adjusted, and no shifting of the line was caused by changing the position of the spark. The edge of the fluting *could not* be brought into coincidence with the nebular line. No measurement of the difference of wave-length was made, as my attention was directed to the main fact of the non-coincidence of the line in all positions of the instrument. I will make such measures as soon as possible."

"Note on the Photographic Spectrum of the Great Nebula in Orion." By WILLIAM HUGGINS, D.C.L., LL.D., F.R.S., and Mrs. HUGGINS. Received April 16,—Read June 12, 1890.

From an examination of the photographs of the spectrum of the nebula in Orion taken by us in 1882, 1888, and 1889, we suggested in our paper "On the Spectrum, Visible and Photographic, of the Great Nebula in Orion,"\* "that the mottled and broken-up character of the nebular matter shown in Lord Rosse's drawings from eye-observations, and much more strikingly brought out in the recent photographs of Mr. Common and of Mr. Roberts, may be connected with differences of spectrum in the photographic region, though in the visible region there is no known alteration of the spectrum of the four bright lines, except it may be some small differences of relative brilliancy of the lines. Until next winter we cannot go beyond the new information which these photographs give to us."

Unfortunately, the necessity thrown upon us of making a laborious redetermination of the position and character of the principal line in the visible spectrum,† which has confirmed in every point the results contained in our paper of last year (*loc. cit.*), has deprived us of the more favourable opportunities during the past season of carrying out our intention of photographing the spectra of different parts of the nebula.

We have obtained two photographs only, one taken on March 14th and 15th, and the other on March 17th; but these suggest how much

\* 'Roy. Soc. Proc.,' vol. 46, p. 42.

† 'Roy. Soc. Proc.,' vol. 47, pp. 129 and 189, &c.

information a spectroscopic examination by photography of the nebula in detail would probably give to us.

These photographs, taken of almost the same part of the nebula as the photograph of 1889, showed, to our surprise, the lines of hydrogen at  $h$  and at  $H$  strongly impressed upon the plate, though these lines were carefully searched for in vain in our former photographs; in them no trace of these lines could be detected, but the line near  $G$  was strong, and there was present a large number of faint lines, of about thirty of which the approximate measures were given in our paper.

The new photographs show not only the lines of hydrogen at  $h$  and  $H$ , but also the first two lines of the ultra-violet series in the white stars which I described in 1879.\* Four of these lines had been photographed in the spectrum of hydrogen by Dr. H. W. Vogel, in 1879, and the entire series, with the exception of one, has been since obtained by Cornu in exceptionally pure hydrogen.†

The line  $\alpha$  at  $\lambda$  3887.8 is strong, and the next line  $\beta$  at  $\lambda$  3834.5, though much fainter, is certainly present. There is evidence of light-action on the plate at the position of the line  $\gamma$  which we believe to be present; and we suspect, from traces of photographic action, that one or more of the other lines of the white star series might have come out with a longer exposure.

It is not necessary to point out in the present note the importance of the presence of these more refrangible lines of hydrogen in respect of the view we have to take of the condition of things in the nebula. In this connexion it is significant that the hydrogen lines are sensibly stronger and broader on the plate as the Trapezium with its stars is approached.

Between the hydrogen lines  $\alpha$  and  $\beta$  there is a line stronger even than  $\alpha$ , which has a wave-length of about  $\lambda$  3868.

We do not find any line in the photograph exactly at the place of the solar line  $K$ ; the position of this line appears to correspond to a gap between two lines on the plate. We suspect the broad line on the less refrangible side of the place of  $K$  would probably be resolved by a narrower slit into two or more lines.

The strong line which was first seen in our photograph of the nebula taken in 1882 is certainly stronger than  $H\gamma$ , and is by far the most powerful line in the photographic region. On account of the wide slit employed in my original photograph, I put the line at about  $\lambda$  3730; from measures of the line in a photograph taken in 1889, with a narrower slit, we found that its position was more refrangible, and we gave the approximate wave-length "about  $\lambda$  3724." There was necessarily some difficulty in determining its position

\* 'Phil. Trans.,' 1880, p. 669.

† 'Journal de Physique,' 2nd ser., vol. 5, Aug., 1886.

exactly on account of the small scale on which, from the faintness of the light of the nebula, it is desirable with the telescope at our disposal to take the photographs, and also because in the nebular spectrum itself we had no fiducial line nearer than  $H\gamma$ . In the photographs taken this year we have the advantage of the known position of the hydrogen line at  $H$ , and with the help of this line our recent measures show that the "about" must be interpreted as slightly less refrangible than  $\lambda$  3724. Without attempting to fix its position absolutely, we believe that the line will be found to fall between  $\lambda$  3725 and  $\lambda$  3726. It is not needful to point out that measures of these little photographs cannot compare in accuracy with direct comparisons with considerable dispersion, as in the case of our observations of the chief line of the nebula by eye. It is, however, now certain that the line does not coincide with any one of the three components of the magnesian oxide triplet, but is less refrangible than the middle line at  $\lambda$  3724, and falls between this line and the first line of the triplet at  $\lambda$  3730.

In these photographs there is a strong line, besides many faint lines, on the less refrangible side of  $G$ .

The background of the spectrum is seen to contain numerous faint lines, which, as far as we have been able to identify them, are the same as those seen in our earlier photographs, of some of which approximate measures were given in our paper, but they are, possibly on account of a slightly wider slit, not so easily measured as they were in the former photographs, in which no traces of the hydrogen lines at  $h$  and at  $H$  could be detected.

A marked feature of the lines consists of their abruptly different intensities at different parts of their length, giving the blotchy appearance which is characteristic of the lines in the visible spectrum, and which we have described in our recent paper "On a Redetermination of the Position and Character of the Principal Line in the Spectrum of the Nebula in Orion." The length of the slit takes in a large angular extent of the nebula, and, therefore, usually includes within it one or more of the brighter "mottlings" which are so well shown in photographs of the nebula. It is to be remarked that these brighter blotches are sharply bounded, showing that the different parts of the nebula are to some extent distinct and often become suddenly brighter than the neighbouring parts.

The lines of the new photographs contain two very strong and abruptly-bounded blotches, and a third one less marked.

These brighter blotches, corresponding to different conditions of closely-adjacent nebular matter, give an explanation of an appearance which we recorded last year in speaking of the strong line "about  $\lambda$  3724." "On one side of the star-spectra this line is a little broader than on the other side; but, as a similar appearance is presented by

H $\gamma$  and the stronger lines of the group, it may arise from some optical or photographic cause.”\*

We now learn that this difference between two parts of the lines indicates probably a different condition of the nebula on the two sides of the star-spectra.

Other lines besides those described in this note are present, not only between G and F, but also on the more refrangible side of the strong line about  $\lambda$  3725.

The importance of the new points which have come out from these photographs makes us regret that we must postpone a fuller examination and discussion of the spectrum of different parts of the nebula until its return next year.

“On a new Group of Lines in the Photographic Spectrum of Sirius.” By WILLIAM HUGGINS, D.C.L., LL.D., F.R.S., and Mrs. HUGGINS. Received April 25,—Read June 12, 1890.

In 1879,† I gave an account of a series of broad lines in the photographic region of the spectrum which was found to be characteristic of Sirius, Vega, and other white stars, and which was identified as a continuation of the spectrum of hydrogen beyond H. $\dagger$  In the photographs of Sirius which I had taken up to that time, I was not able to be certain if the two most refrangible of the lines,  $\theta$  and  $\iota$ , were present. This uncertainty has been set at rest by photographs taken since, in which the complete series of the hydrogen lines, including  $\theta$  and  $\iota$ , come out with great distinctness.

I have long suspected the presence of another group of broad lines some distance further on in the ultra-violet region, but until this year we have not been able to see them in the photographs with sufficient distinctness to be able to make even roughly approximate measures of their positions.

On April 4th, a photograph of the spectrum of Sirius was taken with a long exposure, the slit being made very narrow, in the hope of bringing out this new group of lines with greater distinctness. This plate shows, on examination, that the spectrum of Sirius, after the termination of the hydrogen series, remains, as far as we can see at present, free from any strong lines until a position as far in the ultra-violet as about  $\lambda$  3338 is reached, at which place appears the first of a group of at least six lines, all nearly as broad as those of the hydrogen series. The third line of the group about  $\lambda$  3278 appears to be

\* ‘Roy. Soc. Proc.’ vol. 46, p. 54.

† ‘Phil. Trans.’ 1880, p. 669.

‡ H. W. Vogel, ‘Berlin, Akad. Monatsber.’ 1879, July 10; and Cornu, ‘Journal de Physique,’ 2nd ser., vol. 5, 1836, p. 100.